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The Journal of HEREDITY

A monthly publication devoted to Plant Breeding Animal Breeding and Eugenics

"CORRUGATED" ORANGES

(See Page 415)

Mendel, the Man
Paul Popenoe

Segregation in Halfbred Sheep
J. E. Nichols

Production Records of Jersey Cattle

Twisted Seedlings in Maize
Paul Kvakan

An Alfalfa Bud Mutation
L. R. Waldron

NOVEMBER, 1925 Vol. 16, No. 11

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THE GREGOR MENDEL MEMORIAL

Frontispiece

"Opposite the little garden where he worked happily among his flowers and bees."
From *Gregor Johann Mendel,* by Hugo Iltis.

MENDEL, THE MAN

A Review

IN northeastern Moravia, near the point where the boundaries of Czecho-Slovakia, Germany, and Poland join, is a peaceful agricultural region known as the Kuhländchen whose population, partly Slav and partly German in origin, devotes itself to dairying and some fruit growing.

Here, since at least the sixteenth century, has been found a family of prosperous peasants named Mendel. It was apparently of South German ancestry—from Wurtemburg, according to some. Since 1683 it has been settled in Heinzendorf, a neat village boasting some seventy houses.

Anton Mendel, born in 1789, took part in the later Napoleonic wars, in the course of which he saw much of the world. Returning to settle on the ancestral acres, he married in 1818 Rosina Schwirtlich, daughter of a neighboring gardener. She gave birth on July 22, 1822, to her second child, a son, Johann Mendel, who was to make the family name immortal by attaching it to "Mendelism."

So little has been generally known, hitherto, about his life that he was in a fair way to become a legend. It is extremely fortunate that Hugo Iltis, a resident of the city (Brunn) where Mendel spent his active years, has undertaken to gather all the information extant about him. In this he was helped not only by many of Mendel's pupils, who are still living, but by two of the botanist's nephews, who themselves have taken a justifiable pride in making better known the life of the greatest representative of their family. Dr. Iltis has carried on his work painstakingly for many years, and it is unlikely that much will be added to it in the future. He has brought the material together, and completed it by a survey of the development of "Mendelism" since its founder's death. Every geneticist will want to possess the book,* which was published partly at the expense of the Czecho-Slovakian government.

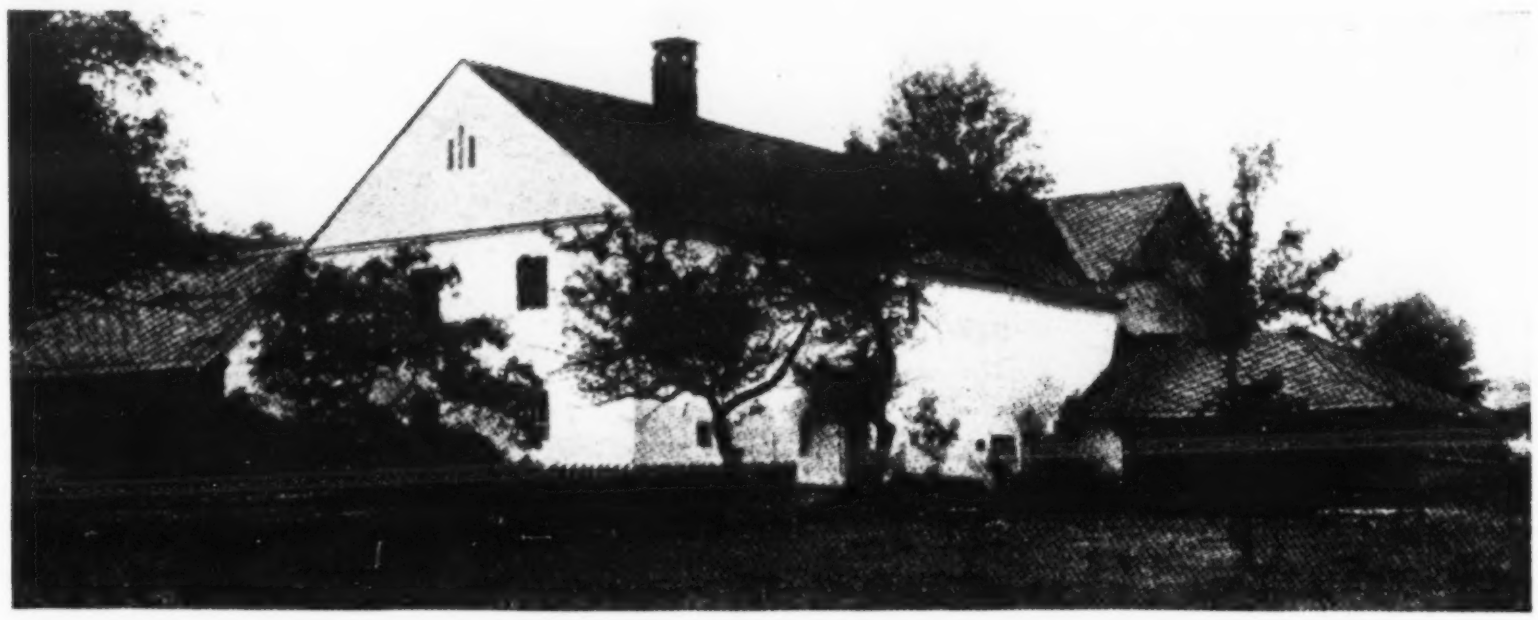
Johann Mendel's characteristics seem to be explicable by his ancestry as is the case with all other living things. He was short in stature, but broad-shouldered and vigorous, like his father. His curly, blond hair and blue-gray eyes are held to be evidence of Nordic race. His mental traits seem to have come largely from his mother's side; and her uncle who, from a simple peasant, had risen by force of energy, persistence, and self-tutoring to become the principal schoolmaster of the region, is pointed out as particularly foreshadowing some of the botanist's traits.

A Born Gardener

Coming of a family which devoted itself to gardening—while most of its neighbors were inclined rather towards dairying—Mendel naturally absorbed in childhood a love of plants, which remained one of his most marked characteristics throughout his life. And he had many of the typical peasant qualities—industry, thrift, patience, and thoroughness.

Johann took well to the life of a gardener, and his father looked forward to seeing him take over the family plot of ground in due time. His mother, however, hoped that her son might reach a little higher position in the world, and by her insistence he was at the age of eleven put in a neighboring school. He made a credit-

*GREGOR JOHANN MENDEL, Leben, Wirk, und Wirkung, von Dr. Hugo Iltis. Pp. 426, with 59 illustrations and 12 tables, price $1.00. Berlin, Verlag Julius Springer, 1924.



MENDEL'S BIRTHPLACE
Figure 1

Located in the village of Heinzendorf, in the "Kuhlaendchen," an agricultural region in northeastern Moravia. From Iltis' *Gregor Johann Mendel.*

able though not a distinguished record, and in the following year was sent to the Gymnasium at Troppau.

Here he showed himself to be a good student; but to maintain him in school was a severe strain on the family's slender resources. He was given accommodations at half-price, his family sent over provisions at frequent intervals, but the young student often went hungry. In 1838 the family, as the result of some reverses, was unable to contribute anything more to his education, and the sixteen-year-old boy was thrown upon his own resources. He sought outside work, and continued in school, supporting himself by strenuous efforts for the remaining two years, returning home during the summer vacations to work in the fields.

The strain was great, and several times he broke down, but in spite of illness he managed to stand near the head of all his classes, save in religion, where he was graded as only "good." He went in 1841 to a college at Olmuetz to take the philosophical courses which had not been offered at the gymnasium. The two years here were marked by further breakdowns, in spite of which he kept on; but by the time of graduation he felt that he had not strength to pursue his studies farther, under the existing conditions. The university was still ahead of him, and it appeared that he would have to give up the career of a teacher, on which he had set his heart.

Enters the Augustine Order

He confided his difficulties to his philosophy teacher, who had been in the convent at Brunn, and who suggested to Mendel that he should take holy orders. There seemed no other way open, by which he might pursue his studies, and although religion and philosophy had interested him much less than the natural sciences, he determined to enter the brotherhood. In 1843 he was admitted as a novice, and given the name of Gregor, which he thereafter used in front of his baptismal name.

Fortunately Brunn—a provincial capital and the seventh city of importance in Austria at that time—had an active intellectual life, and the convent itself was the home of learning, to an extent that was common enough in the Middle Ages but has since become rarer. Mendel therefore found himself not among bigoted zealots, but among devotees of literature and science, many of them men of the world. The prelate in particular was a man of high authority and ability. He saw in a short time that Mendel would never make anything more than a mediocre "curate of

souls"—indeed, he was almost excluded from this work because he could not stand the sight of suffering, and promptly became sick himself if called on to attend one in illness. He had, however, an unquenchable interest in the natural sciences, and the abbot was broad-minded enough to see that he would be useful as a teacher in this field. He therefore encouraged him in this direction, and although Gregor took the theological course, he absorbed no missionary zeal. He remained a Liberal in politics, and had no great respect for the pomp and hierarchy of the church—indeed, he once had to be disciplined because he commented that a visiting bishop was more distinguished by his fat than by his learning.

He was soon assigned as assistant teacher of physics on one of the neighboring secondary schools, and became extremely popular with both faculty and students. He had not yet, however, received a teacher's certificate, and for this purpose was obliged to go to Vienna, to be examined in natural sciences by members of the university faculty. They promptly "flunked" him! In fact, he was largely self-taught in this field, had had access to few books, and his knowledge was more or less fragmentary and unsystematized.

It is interesting to learn from his examination that even in 1850—nine years before the publication of *The Origin of Species*—he had definitely adopted the evolutionary point of view of geology that was taught by Charles Lyall.

It was evident that the young priest needed some systematic training in his chosen field, so the convent arranged to send him to the University of Vienna for a year of special study. He seems to have done creditably there, but little is known of his university life. On one occasion, however, he writes that he had just purchased a lottery ticket. He returned to Brunn and was appointed assistant in the technical high school, where he remained for fourteen years—probably the happiest, as well as the most productive years of his life.

There is no doubt that he was beloved by his pupils. They agree on his tranquil, friendly nature, his clear and well-ordered lectures, and the great interest he took in helping his students outside of the classroom. He taught zoölogy, botany, and physics, and a number of his pupils who afterward adopted a career in science testify that it was Mendel who really awakened their interest in nature.

His Home a Laboratory

He dwelt in two rooms at the convent, and these he had turned into a laboratory for nature study. The visitor found them full of cages containing birds, white and gray mice, and any animals that came his way—among them a tame fox, and even a porcupine. In the garden he had his bees, his flowers and fruit trees; he grew pineapples in a hot house; and had installed near it a delicate aeolian harp which responded to every breeze.

In 1856 he went to Vienna again to take an examination for a teacher's certificate. What happened is unknown, but he came back sick, with his head swathed in bandages, and announced that he had again failed to pass. There is a legend that he had engaged in a controversy with the professor of botany, which aroused the latter's animosity. He continued teaching, but remained an assistant—he was never able to advance to full faculty standing.

By this time he had already begun systematic experiments in many lines, mostly with plants. Many of these are known only from chance remarks that he made to his associates. He demonstrated to his classes, for example, that a poisonous plant became less poisonous if it were transplanted several times. He discussed with one of his friends, on numerous occasions, the problem of the origin of species, and attempted to throw light on it by

transplanting weeds and flowers of all kinds, to find whether the change in their environment produced any permanent variation. For many years he grew several wild species of Ranunculus, alongside the cultivated form in his garden, to find whether the former would become any more like the latter in appearance. The results were negative. "I can see," he told a friend, "that Nature does not move in this direction, in species-making. There is something more to it."

When Darwin's books began to appear, he bought them all (in spite of the fact that they were prohibited to good Catholics) and studied them attentively. He agreed with their general conclusions, says one of his colleagues, but thought that there was still something lacking in the theory of natural selection. These books, with his annotations, are yet in the convent library, as are many other scientific works of the period. Indeed, it appears that he got hold of most of the literature in his line. For *belles lettres*, however, he had no more taste than for music and art—his inclinations were wholly scientific.

The origin of his famous experiments with peas is unknown. As early as his university year he had contributed to a scientific society a paper on an insect pest of garden peas, which suggests that he had begun work with this legume before that time. It is interesting to note that some years later this same beetle very nearly brought his pea cultures to an end.

Dr. Iltis ingeniously suggests that Mendel may have discovered the segregation of characters first through crossing his mice, and that, fearing to arouse the hostility of some of his more pious colleagues through hybridization experiments with animals, he adopted peas as a material less likely to incur opposition. He knew that the bishop, whom he had ridiculed on a previous occasion, would have no friendly feeling toward him, but perhaps felt that flowers would be found inoffensive, even by the most captious critic.

His little garden, 35 meters long by 7 wide, is well known. It soon became the center of his interest. When visitors came to his apartment, he used to love to shock them by a joke based on the fact that he was vowed to celibacy. "Before you go, I want you to see my children," he would say, and then lead them to the garden, where the pea vines sprawled in every direction.

Scientific Activities

While the classical experiments with peas, which probably began as early as 1854, held the center of the stage, they by no means absorbed all his time. He had undertaken to make daily meteorological observations, and he carried on this task until a few days before his death. He had also his bees—not only the local race, but a wild species and the domesticated races of Carinthia, Italy, Egypt, and Cyprus. Beside each of the many hives hung a record sheet, which he kept up in his methodical and painstaking way, setting down such facts as the date of introduction of a queen, the date of swarming, the hours at which the drones flew, and other observations that might be useful to him in his real work, which was hybridization. Unfortunately, no records of the results he achieved have been preserved.

His experiments with flowers were by no means confined to peas, although these were continued longer than any others. In addition to Hieracium, on which he published, his letters to Naegeli show that he had worked with some 30 other genera.

From first to last, the record proves that he was a true nature-lover of the old-fashioned type, and a born plantsman. No interesting plant escaped his eye, and he brought back from his occasional field trips with colleagues or students many specimens that found a place in his little garden. On a

40 Separatabdr.

Versuche
über
Pflanzen-Hybriden
von
Gregor Mendel.
(Vorgelegt in den Sitzungen vom 8. Februar u. 8. März 1865).

Einleitende Bemerkungen

Künstliche Befruchtungen, welche an Ziergewächsen behufs neuer Farbenvarietäten vorgenommen wurden, um neue Farben-Varietäten zu erzielen, waren die Veranlassung zu den Versuchen, welche hier besprochen werden sollen. Die auffallende Regelmässigkeit, mit welcher dieselben Hybridformen immer wiederkehrten, so oft die Befruchtung zweier ähnlicher Arten geschah, gab die Anregung zu weiteren Experimenten, deren Aufgabe es war, die Entwicklung der Hybriden in ihren Nachkommen zu verfolgen.

Dieser Aufgabe haben sorgfältige Beobachter, wie Kölreuter, Gärtner, Herbert, Lecoq, Wichura u. a. einen Theil ihres Lebens mit unermüdlicher Ausdauer gewidmet. Namentlich hat Gärtner in seinem Werke „die Bastarderzeugung im Pflanzenreiche" sehr schätzbare Beobachtungen niedergelegt, und in neuester Zeit wurden von Wichura gründliche Untersuchungen über die Bastarde der Weiden veröffentlicht. Kaum ist es auch nöthig hervorzuheben, wie allgemein gültiges Gesetz es für die Bildung und Entwicklung der Hybriden aufzufassen, so kann das Nichtwissen Jedem, der das Umfangs der Aufgabe kennt und die Schwierigkeiten zu würdigen weiss, mit denen Versuche

MENDEL'S HANDWRITING

Figure 2

First page of the original manuscript of his "Studies of Plant Hybrids," the note, "40 separata" was added by the editor, G. von Niessl. Dr. Iltis found the manuscript of Mendel's classical article in an old box of papers that were to be burned. From Iltis' *Gregor Johann Mendel.*

trip to Italy he enjoyed some grapes that he ate in Florence; he brought the seeds home and grew from them vines that even today are bearing fruit.

His opportunity to develop his taste in this direction came after his election to the prelacy. He then had control of all the grounds, and could improve them as he liked. Scores of fine fruit trees were planted, and a leaden seal with the letters G. M., attached to many a limb, shows to this day how he budded and grafted them with his own hands. His gardener states that he made cross-pollinations of many of his trees—500 or 600 altogether, planting the seeds and sometimes grafting the seedlings on his older trees. He displayed his own vegetables at gard ning exhibitions, acted as judge at flower shows, and is universally remembered as a flower-lover; indeed, when a photograph of the members of the order was taken, Mendel chose to be represented with a Fuchsia in his hand.

As a long-time member and vice-president of the local Beekeepers' Society, he went to Kiel, even when abbot of the convent, to attend a convention of German Apiarists.

His interest in biology naturally extended to men. He made studies in the heredity of old families of Brunn; and regularly took anthropological measurements of his two nephews.

Elected Head of Convent

The active life of scientific research and teaching, which the priest found so much to his liking, was interrupted in 1868 by his election to the position of abbot of the convent. At first sight it would appear that no more inappropriate choice could have been made, for a high clerical office, than that of the independent, liberal-minded naturalist, of humble origin, and as unknown in clerical as he was in political circles. The position was one of great importance, carrying with it unusual influences and many unofficial as well as official duties and privileges.

There were, however, only twelve men among whom a choice had to be made. Mendel seems to have had many friends and no enemies; and he was still a young man. It was the custom to select a young man for the position, in order to avoid too frequent changes due to death; for the government took a heavy tax from the property of the order, in connection with the installation of each new head.

So it came about that the poor country boy, who had worked his way through school and eventually joined the order because he could not afford to get an education in any other way, was raised to rulership over one of the wealthiest foundations in the country; that the young priest, who missed being a farmer for life only by a hair's breadth, was taken from his little rooms full of birds and animals, and installed in a veritable palace, with forty halls and inlaid floors, costly furniture and "old masters;" that the student who, at the gymnasium, had often been supperless was now master of a cuisine famed even in Austria—a country which boasted the best cookery of all Europe.

The young assistant, who had never been able to pass the examination for a teacher's certificate, left his school without saying good-bye; but he asked the director to divide his last month's pay among three of the most deserving poor students. He devoted himself with energy to the management of the many properties which the convent possessed in Moravia; and also to full enjoyment of the perquisites which went with his office. He brought his two nephews to Brunn to be educated at his expense for the medical profession; he gave alms and contributions to all charities that appealed for help; he even became, despite his personal indifference to them, a liberal patron of literature, music and the fine arts!

He had prominent people as guests at his table almost daily, and kept

open house for notabilities on Sunday afternoons. The good living began to stimulate a family tendency to obesity, and the prelate was constantly trying some new scheme to "reduce,"—now rolling on the floor of his bedroom, again forming the habit of rising at 4 o'clock to go to work, and at another time adopting a liquid diet: all of which measures, it may be said, proved useless in overcoming heredity.

Evenings were often given over to a game of chess—his favorite diversion and one, as W. Bateson has remarked, that accorded well with the mathematical nature of his mental processes.

The visits to various properties of the order consumed much time, and on such absences his plants at home sometimes suffered for lack of care. With the thrift of his peasant upbringing, he proved to be a good manager of the estates that the foundation possessed. His wealth allowed him to make any other trips that appealed to him—to Rome, to the Vienna Exposition of 1873 with his two nephews, to Venice, often to the Alps, and even, it is thought, to England.

These occupations, together with the constantly increasing exactions of his official life, gave him little leisure for research. He served on various government commissions for the promotion of agriculture, for education, for the revision of rural taxation; was made a director of an institution for deaf-mutes, and even, in 1876, director-general of the governmental mortgage-bank, in which capacity he had to attend board meetings at 11 o'clock several mornings in the week, sometimes even daily. In all these positions, he made himself invaluable through his adherence to facts, his clear-mindedness, the simplicity and directness of his dealings, and his persevering thoroughness. It is likely enough, too, that he found this activity, and the power that he enjoyed, decidedly gratifying, especially by contrast with his earlier years. He continued to talk about his researches, to plan new ones and lament the lack of time to continue old ones; but they gradually dropped out of his life. His meteorological records were the only ones that he continued to the end.

The Fight Against the Government

After Mendel had enjoyed the pomp and authority of his position for six years, came the event that clouded and embittered the remaining decade of his life. The German Liberal Party, to which the abbot himself belonged (though he was never active politically) introduced a bill in parliament to appropriate surplus funds that were tied up in the great religious foundations, and put them to use in the maintenance of the daily religious ministrations of the country—which, it will be remembered, was officially Roman Catholic. Possibly the measure was intended mainly for effect; at any rate there was a large loophole in it. The foundations were not to be deprived of funds necessary to cover their own fixed charges and maintenance. It was easy enough for them, in filing their returns, to name their total incomes and to state that all of this income was needed for their own work. In such cases the state could take nothing. The other foundations quickly took advantage of this means of escape from a law that was certainly onerous, even if constitutional. But Abbot Mendel refused to be a party to any such compromise.

His opposition to this measure perhaps reflects particularly the fact that he was not born to the career: that he was a man of science rather than a prelate and diplomat. Beyond that, his friends would say that it reflected the uncompromising honesty of his nature; his enemies would reply that it merely showed his head had been turned by the power he had enjoyed. He ignored the law for a long time; and when this was no longer possible, he fought it, answering every communication on the subject with long

arguments in which he attacked its constitutionality.

Those who had at first supported Mendel in his stand began to desert him and make their peace with the state. He never wavered. The state began legal proceedings, and sequestered part of the property of his foundation. He countered by announcing that he was carrying the amount on his book as a loan to the state, on which he would charge 7% interest until the principal was repaid to him.

One by one the remunerative domains of his order were thus confiscated by the state; each act brought forth another long protest from the stiff-necked abbot. It was a case of the irresistible force and the immovable object. People began to whisper that the prelate's reason was failing. The whispers reached his ears, and he bitterly told his intimates that his enemies were charging him with insanity and plotting to murder him. He became something of a recluse, admitting few to his confidence and finding relaxation principally in the company of his nephews. The position of the convent became so uncomfortable that most of the brothers of his own order turned against him, and his bishop charged one of them to make observations secretly on the abbot's mental condition. Mendel alleged that there was a plot to commit him to an insane asylum. The government pleaded with the bishop to take action against him.

But action was made unnecesary by illness to which Mendel succumbed in the middle of 1883. He had to turn over the financial affairs of the order to a steward. Within two weeks after Mendel's death his associates arranged a compromise with the government, recognizing the law and petitioning for the return of the confiscated funds. The result was, in brief, that the government kept its prestige, the convent kept its money.

The Death of Mendel

Mendel died on January 6, 1884, of organic heart trouble, kidney trouble, and hydropsy, to which uraemia was added. Having sought the truth in life, he desired it after death, and demanded that a post mortem be performed to ascertain the real cause of his demise. The operation was also motived, in part, by a fear which he held of being buried alive.

The question whether Mendel's mind was actually unbalanced during his last years is difficult to answer. There was no mental disease in his ancestry, and his nephews, both medical men, who were with him much of the time, are confident that he could not be called unbalanced. He had, however, suffered for years from Bright's Disease (toward which he seems to have had an inherited tendency); and he had also been accustomed for years to smoke twenty cigars a day. It is reasonable enough to suppose that a toxic condition produced some mental disturbance in him.

After the funeral his associates went through his "literary remains," setting aside all well-bound books for the convent library and burning everything else. Thus all original record of his life work was lost, except the two brief contributions that he published, and which were ignored by the world of science until 1900.

Paul Popenoe.

SEGREGATION IN HALFBRED SHEEP

Popular Belief That Halfbred Border Leicester × Cheviot Breeds True Not Confirmed

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THE Border Leicester has long been recognized as one of the most valuable breeds of sheep in the British Isles for cross-breeding purposes, particularly in the production of mutton and one of the most important crosses made is that with the Cheviot. It has been estimated that about 90 per cent of the annual crop of pure bred Border Leicester rams is used for cross-breeding and the bulk of this is with Cheviot ewes. The offspring of this cross are known as "Halfbreds," and though it is not clear when the cross was first made it is known that it had been practiced in the Border Counties of Scotland and England over a hundred years ago. Since that time it has also spread considerably to the more northern counties of Sutherland and Caithness. The term "Halfbred" has not been confined to the first cross of Border Leicester rams on Cheviot ewes, but is also applied, with the qualification "pure bred," to the offspring of those flocks where F_1 (first hybrid generation) ewes have been retained for breeding purposes and the mating "Halfbred" × "Halfbred" been subsequently continued for a number of generations. Thus there are at present in existence in Scotland a number of flocks which have been maintained, without the reintroduction of either of the pure parental strains, for some considerable time and have no doubt been selected to preserve a certain degree of uniformity.

But the assertion is often made, and has been accepted by many authorities, that the "Halfbred" "breeds true," i. e., that the "Halfbred" is an instance of blending inheritance and that there is no segregation in F_2. It has long been necessary to examine this question and it has been possible recently to test the truth of this assertion by the examination of the offspring of F_1 halfbred ewes mated to F_1 halfbred rams.

Characteristics of Parent Breeds

There are distinct points of similarity between the parental breeds, the Cheviot and Border Leicester; there are also well marked differences, the existence of which has been utilized for the purposes of this discussion. Thus fleece character differences are very definite and have been used as criteria for classification of types; the results of a detailed study of the parental and filial types which has been made are not included in the present paper; however, a general description will suffice. The fleece of the Border Leicester is composed of long, soft, lustrous wool, closely set on the skin and possessing an even "purled" character over the whole length of the staple, with definite lockiness; Cheviot wool, on the other hand, is particularly dense, relatively short, demilustrous and exhibiting only slight lockiness, the fleece forms a distinct ruffle or frill well up on the neck. Halfbred wool is of a definite type, intermediate in length between Cheviot and Border Leicester, fairly dense, and with a slight purl which in the best specimens is not so marked in the proximal portions of the staple. The gross appearance of the three types can be distinguished in the illustrations.

Border Leicester Ewe

Cheviot Ewe

Halfbred Ewes

TYPES OF EWES OF PARENT BREEDS AND "HALFBREDS"

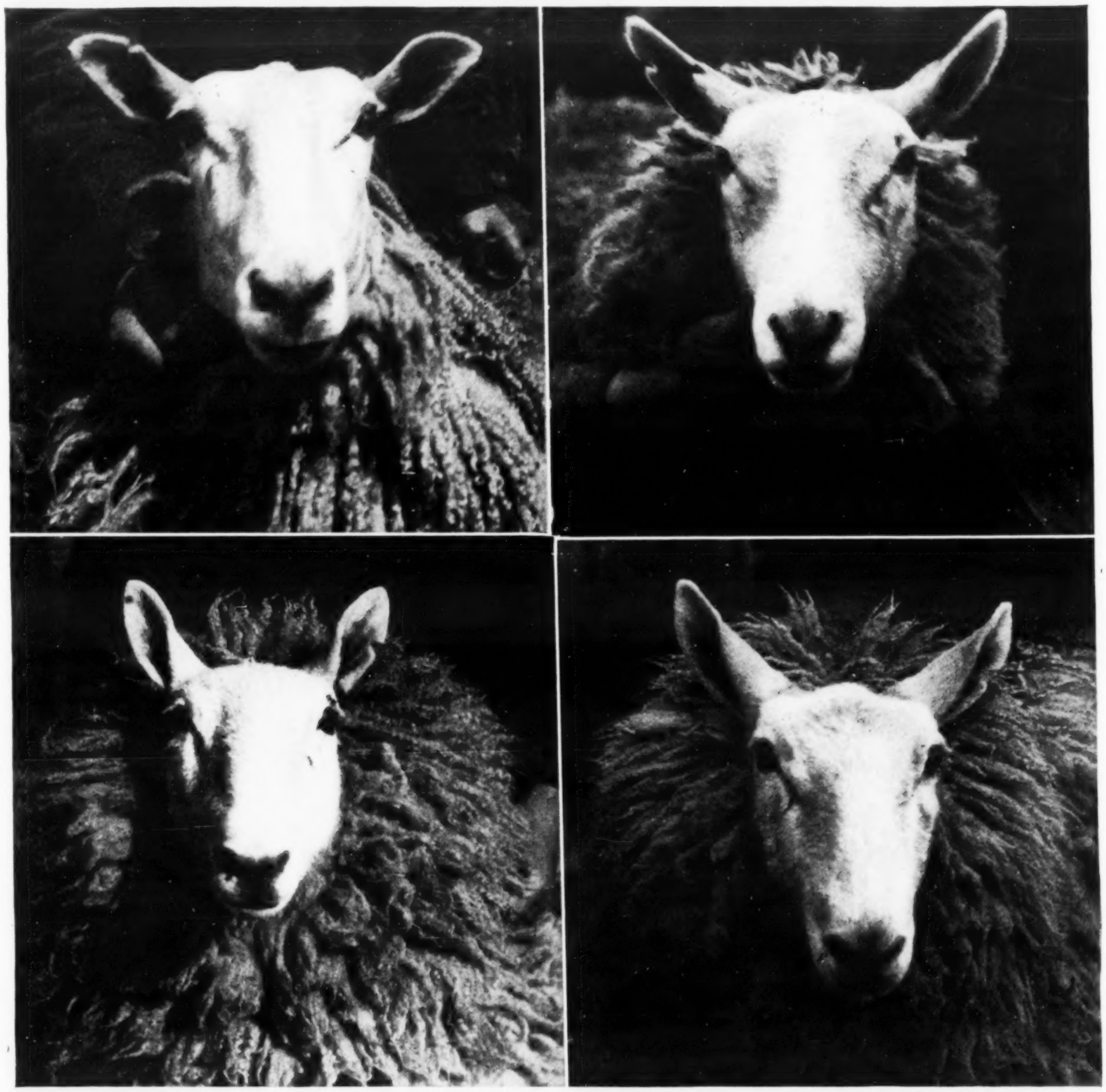
Figure 3

"Halfbred" sheep have long been recognized in the Border Counties of England and as being especially desirable for mutton purposes. Usually Border Leicester rams are mated to Cheviot Ewes but some flocks (the so-called "pure bred" halfbreds) have been maintained by mating inter-se for a number of generations.

In general body conformation the Border Leicester is distinguishable from the Cheviot in that it is longer, not so compactly built, more "leggy," and the neck is longer and more erect; the Cheviot is more squat in form. The Halfbred is intermediate in character. Viewed from the side, in full fleece, the body of the Cheviot appears as a rectangle whose length is not great in proportion to its height, the Border Leicester that of a rectangle whose height-length ratio is further from unity and the Halfbred with height-length ratio of intermediate grade. One of the best marked breed differences is that of head form; for the purposes of comparison photographs of females of the parental and filial types are shown.

Border Leicester Ewe

Cheviot Ewe



Halfbred Ewes

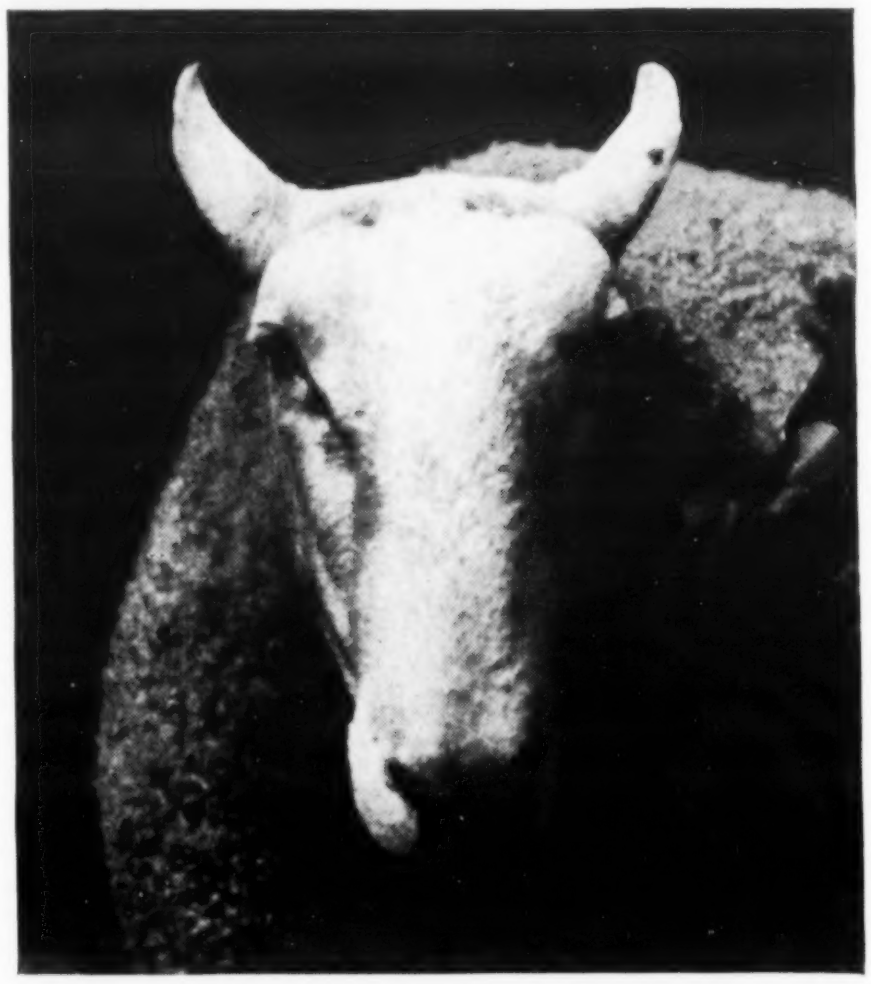
HEAD FORM OF PURE BRED AND "HALFBRED" EWES

Figure 4

The most marked difference between the Border Leicester and the Cheviot is the character of the fleece. That of the Border Leicester has an even "purl" and is long and lustrous. Cheviot wool is dense and short, and the fleece comes up to a definite "ruffle" just behind the ears. The wool of the halfbreds is intermediate and the "ruffle" resembles that of the Cheviot.

Figure 3 shows in profile the head and neck of a typical Border Leicester shearling ewe, and the head and neck of a Cheviot ewe from the flock from which came the dams of the Halfbred ewes studied in this investigation. The profile of the Border Leicester is distinctly aquiline compared with that of the Cheviot, the crown is more accentuated, giving the impression of a more definite poll, the ears are set lower in relation to the crown and eye, while the muzzle is square and the bones of the face are more prominent. The neck is less distinct in the Cheviot and the frill formed by the fleece is more marked and closer to the ears. Typical Halfbred heads, shown also in Fig-

ure 3, exhibit in profile the Border Leicester characters of aquilinity, strong muzzle and boldness of crown to a less degree than the pure Border Leicester and the Cheviot characters of broadness of jowl and fleece frill. Full face views (Figure 4) show clearly the type differences in length of face, breadth between the eyes, squareness of muzzle, set of ears and width of jowl, all of which serve as criteria of distinction. In Figure 5 the head of a typical Border Leicester ram is shown so that the general appearance of length of face may be more fully appreciated. These photographs of the sheep in full fleece also show how definite is the difference in character of the development of the frill.



BORDER LEICESTER RAM

Figure 5

The head of a typical Border Leicester ram. Note especially the extreme length of face—a distinguishing Leicester characteristic.

Segregation in Second Generation

The production of Halfbred lambs is of such economic importance that breeders bestow great care in the selection of Border Leicester rams to mate with their Cheviot ewes and once they have discovered the type of ram which "nicks" well with their ewes, they are most particular always to select that type for use. Figure 6 shows an aged Border Leicester ram, one of the sires of the Halfbred flock under observation; he was used, with others of similar satisfactory "nicking" type, in season 1922 on Cheviot ewes of the type shown in this figure, and from their offspring 114 ewes were sold for breeding purposes to the farmer in whose flock the observations were made. These ewes were mated to two first cross Border Leicester × Cheviot rams, one of which is shown in Figure 6, in 1923. The flock was first examined on April 26, 1924, just at the end of the lambing season, and it was manifest that even in the young lambs there were distinct evidences of segregation, particularly in fleece characters; some of the lambs had the close, short coat typical of the Cheviot, some the open, long coat of the Border Leicester, and the rest of intermediate type. Typical crossbred ewes and their lambs are shown in Figure 6.

On July 31, 1924, after the wether lambs (which had by now practically outgrown any initial differences in size due to slight difference in age) had been drafted off for sale as feeding lambs, they were examined and distinct segregation was found; of 103 wether lambs, 18 were typical Border Leicesters in head form, body conformation and fleece, 64 were typical "Halfbreds," 20 could be described as of "Indefinite Class," but with one closely approximating the Cheviot type except for slight differences in head form and density of fleece, and one was a Cheviot. (It was also noted that 10 possessed well developed loose scurs with no bony core—a condition often found in Cheviot males.) The "Indefinite Class" consisted of animals with Border Leicester fleeces on Cheviot bodies (including heads), Border Leicester fleeces on Halfbred bodies, Cheviot fleeces on Border Leicester bodies, Cheviot fleeces on Halfbred bodies and Halfbred fleeces on Cheviot and Bor-

Border Leicester Ram | Cheviot Ewe

Halfbred Ram | Halfbred Ewe and F_2 Lambs

PURE BREDS AND HALFBREDS

Figure 6

The pure breds are of the types used in making these crosses. The F_1 ram is a good example of the halfbred type, and was used in mating to halfbred ewes. Even when quite young the F_2 lambs showed evidences of segregation.

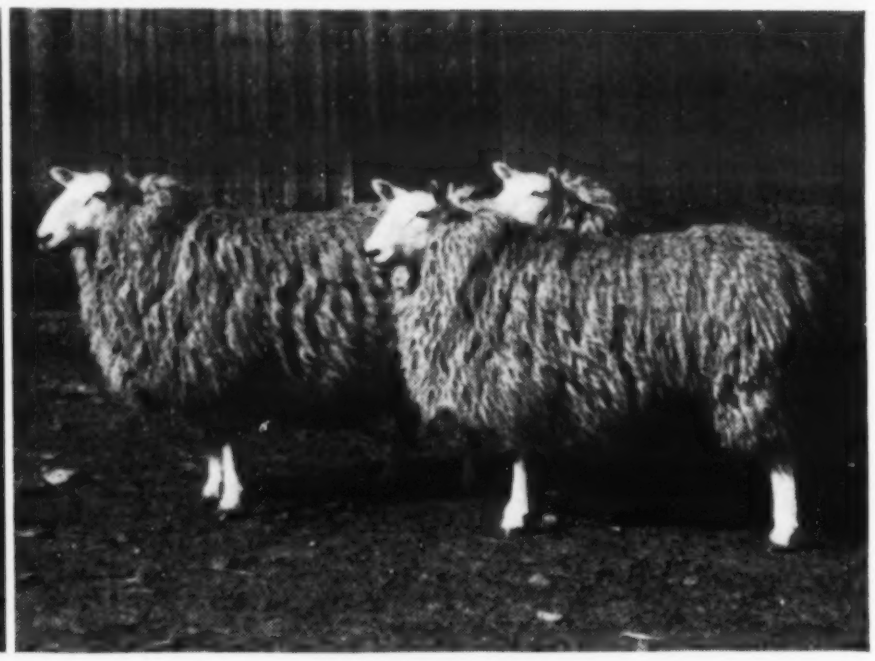
der Leicester bodies; the demarcations of types were not sufficiently definite to warrant separate classification, but the last two types—Halfbred fleeces on Cheviot and Border Leicester bodies—were comparatively few in number. The ewe lambs were all kept over the winter and were examined on April 16, 1925. Here again there was almost complete segregation; out of 83, 16 were typical Border Leicesters, 51 were Halfbred, 16 were "Indefinite Class," with 2 of this class closely approximating Cheviot type. Thus the total numbers of the classes in F_2 were Border Leicester 34, "Halfbred" 115, Indefinite 36 (with 3 almost typical Cheviots) and Cheviot 1.

The ewe lambs particularly exhibited the well marked differences which existed between the classes; Figure 7 shows random samples of the four classes. In the Border Leicester class, the long, open, purly type of fleece with the long body, high-carried head and neck and the pronounced aquiline, crowned profile are easily distinguishable. The association of Border Leicester fleece with Cheviot body, frill, and Cheviot head is found in the "Indefinite Class," especially in the sheep on the left.

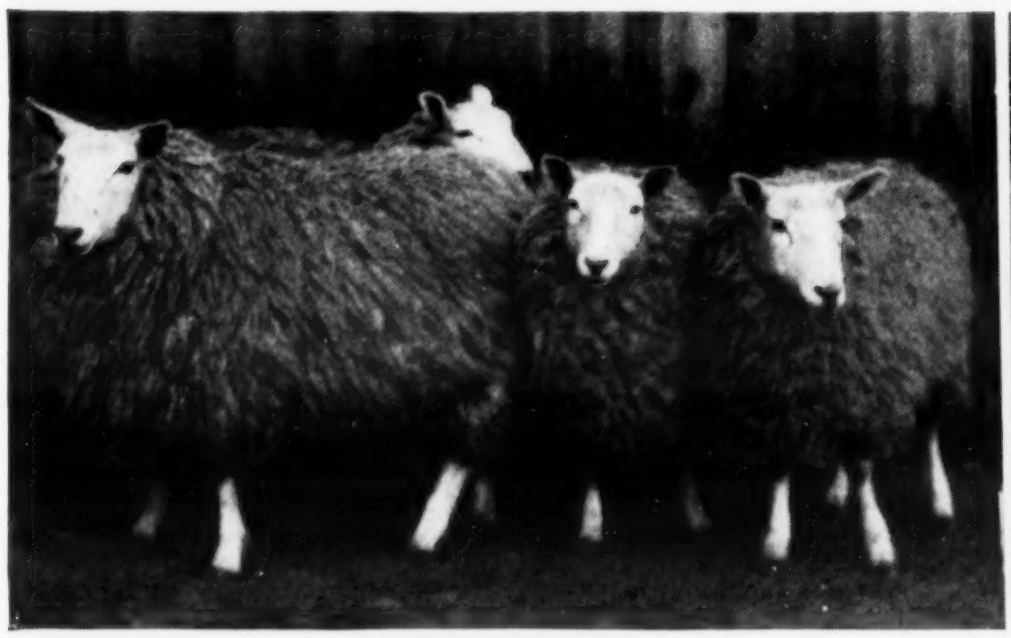
Discussion

Differences in characterization between the Border Leicester and the

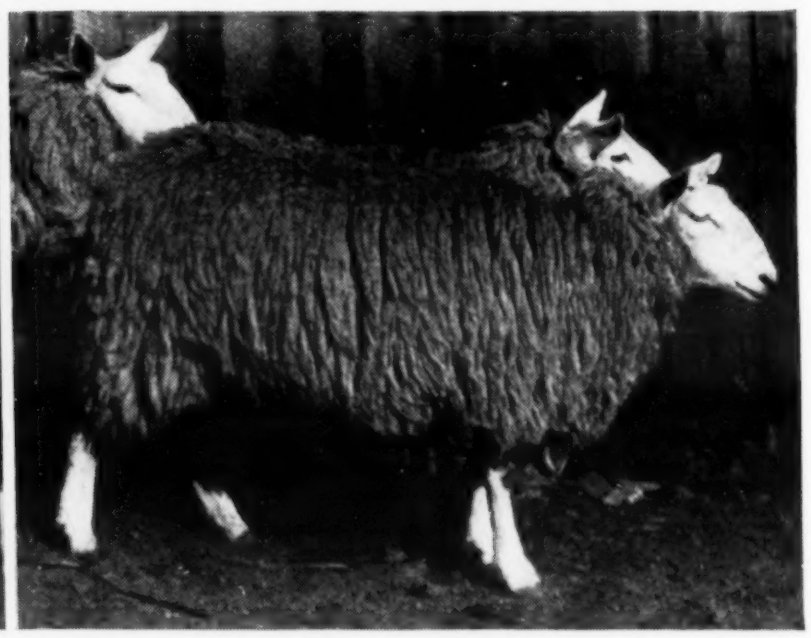
Border Leicester Type



Halfbred Type



Intermediate Type



Cheviot Type

SEGREGATION IN THE SECOND GENERATION

Figure 7

It is popularly believed that the Halfbred is an example of blending inheritance and shows no segregation in the perjugate generations. Nevertheless definite segregation was found, and the four classes shown above were fairly read ly distinguished.

Cheviot are many and are sufficiently clear cut to be significant in a study of this nature; the mode of inheritance of particular structures has not been followed particularly, rather have those characters which, in toto, constitute the parental types been studied. In the F_1 some variation was found, particularly of details of fleece characters, but this variation was restricted to a range strictly intermediate between the parental types, though the F_1 ewes had been roughly selected for uniformity, none could be described as exhibiting the true parental characters in any way completely. In the F_2 the range of variation was considerably increased and individuals clearly coming within the parental types were found; the numbers in the classes found in F_2, especially when one considers the fact that many of those classed as "Indefinite" exhibited many definite Cheviot characters to a marked degree, are very significant and furnish definite evidence of segregation. These results closely coincide with the observations of Ritzman on his crosses with Rambouillet and Southdown sheep and with the indications of Mackenzie and Marshall's experiments on the inheritance of mutton points in crosses of Merino and Shropshire sheep. The conclusion may be drawn that in regard to general body conformation a number of major factors are involved and the degree of their expression is influenced by a

considerable number of modifying factors. Thus it would appear that in the Border Leicester × Cheviot cross the small height-length ratio of the body rectangle of the Border Leicester is incompletely dominant to the larger height-length ratio of the Cheviot since in the F_2 the two classes Border Leicester and "Halfbred" and also some of the Indefinite class possess a lower height-length ratio than the rest, and this is very definitely marked in the first class. Also the segregation of the short legged type is well marked in F_2 and would appear to be incompletely recessive to the long legged type.

The inheritance of profile has been studied by Pucci, who found that the convex profile of the sheep of the Middle Tiber Valley was a simple Mendelian recessive, allelomorphic to the straight profile of the Rambouillet. In the cross here studied it would be daring to propose such a simple explanation, but there are indications that the less aquiline profile of the Cheviot is to a certain extent dominant to the more pronounced aquilinity of the Border Leicester, and also that the flat crown and breadth between the eyes of the Cheviot are dominant to the contrasting characters in the Border Leicester, while the long face of the latter is imperfectly dominant to the short face of the former. In general face character the rugged contour of the Border Leicester may be said to be incompletely dominant to the smoother contour of the Cheviot.

In fleece characters the most outstanding features are the almost complete dominance of the Cheviot frill and the segregation of types in the F_2; providing close agreement on this second point with the observations of Völtz and Baur and Kronacher on the "Meleschaf" (Leicester × Merino) of Germany. The very extreme forms are rare, such as the typical dense Cheviot fleece and the "purly" Border Leicester. By far the great majority of the F_2 forms are intermediate, which result must be attributed to a large number of multiple factors. Until the results of the detailed analysis of the fleece samples are fully available, it is unjustifiable to make further statements on the behavior of fleece characters in inheritance, though length of fleece may be said to be dominant in this cross.

From the description given above of the different types which emerge when first cross Border Leicester × Cheviots are mated together it is manifest that the assertion that the "Halfbred" exhibits a form of blending inheritance, or, as is sometimes more boldly stated, that the "Halfbred" "breeds true" has no foundation in fact, when one considers the first cross animals or true Halfbreds. At the same time, it must be admitted that in certain flocks the mating Halfbred to Halfbred has been carried on for many generations, as has already been pointed out, and in these flocks by selection almost pure breeding strains have been formed. Many of the animals from these flocks have proved themselves superior even to the first crosses, both in the show ring as mutton sheep and as breeding animals, but this may serve merely as a further illustration of how a strain may be developed. This is only a matter of careful selection and time and does not in any way detract from or antagonize the truth of the statement now put forward that the Halfbred is indeed only a further example of the behavior of characters in sheep in inheritance according to the Mendelian laws of segregation and recombination of a number of factors just as is the case of ear length in rabbits as described by Castle.

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Materials of Genetics

Genetics is a new science dealing with variations in plant and animal life mostly difficult to preserve or to present as illustrative material for instruction. This difficulty of providing suitable subject-matter is one of the chief obstacles to proper instruction in the subject. Illustrations are scattered widely in scientific journals—THE JOURNAL OF HEREDITY affords the largest body of photographic material,—but these should be supplemented by other reference sources as far as possible.

A notable addition to the available sources of genetic material has just been issued by the Cambridge University Press, "Experiments in Genetics," by Charles Chamberlain Hurst,* a collection of 38 papers covering a period of 30 years of investigational activity, from 1894 to 1925, though most of the experiments were interrupted by the war, in 1914.

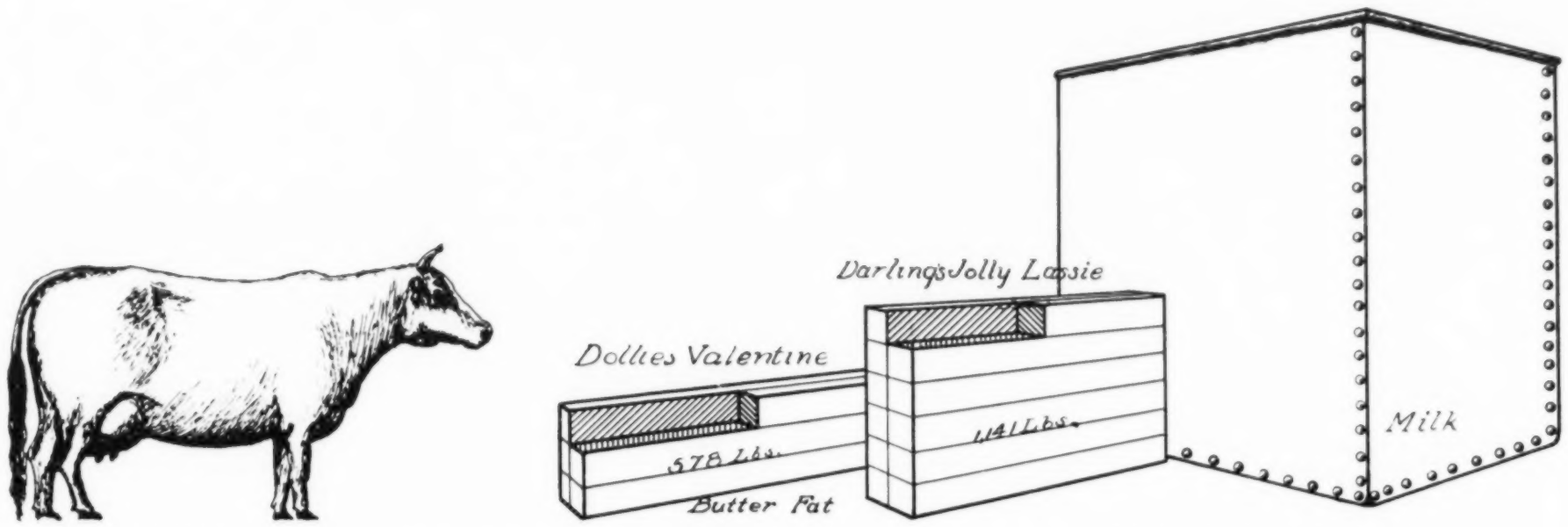
Several of the papers relate to experiments with orchids, and are of special interest as a continuation of the work of Darwin. The excellent illustrations include representatives of many of the orchid genera and of generic and specific hybrids. Even where collections of the plants are not available, students of genetics may get an introduction to the weird orchid world that challenged and inspired the curiosity of Darwin and many of his followers.

In addition to the orchids, the papers cover a wide range of experimental data, relating to numerous plants, and animals and to a series of systematic observations on human heredity. The plant experiments deal largely with peas, snapdragons, tomatoes, wheat, and roses, while poultry, rabbits, and horses are treated extensively in the animal papers. The data of human heredity relate chiefly to eye-colors, hair colors, skin colors, musical sense, left-handedness, and disease susceptibility. Some of the papers treat of general subjects, as Mendelism and sex, or applications of genetics to practical problems. Most of the data and discussions relate to Mendelism and reflect in many interesting and instructive ways the development of ideas of heredity during the Mendelism period.

O. F. C.

*HURST, CHARLES CHAMBERLIN. Experiments in Genetics. Pp. xxiv+578. Price fifty shillings. The Cambridge University Press. 1925.

PROGRESS IN MILK AND BUTTER-FAT PRODUCTION



A YEAR'S MILK AND BUTTER PRODUCTION BY RECORD-HOLDING COWS

Figure 8

If the butter-fat were made into "quarters," as butter is sold at the corner grocery, one hundred pounds would be a piece approximately six inches square and seven feet long. The milk produced by Darlings Jolly Lassie would fill a rectangular tank five feet by seven feet and eight feet high. Another Jersey cow, Madeline of Hillside, recently produced 20,620 pounds of milk in a year; but only 1,044 pounds of fat.

THE development of the modern breeds of livestock has been rapid during recent years. Selection has been directed principally toward maintaining a certain "type," which represents a complex of characters. Probably the race-horse represents the oldest and most spectacular case of selection for one specific quality—speed. Doubtless this rests on a number of factors for size, musculature, nervous development, and so forth. The interesting point was made recently by Dr. Anderson that forty-eight years were required to breed a race-horse that would reduce the time for a mile by seven seconds.*

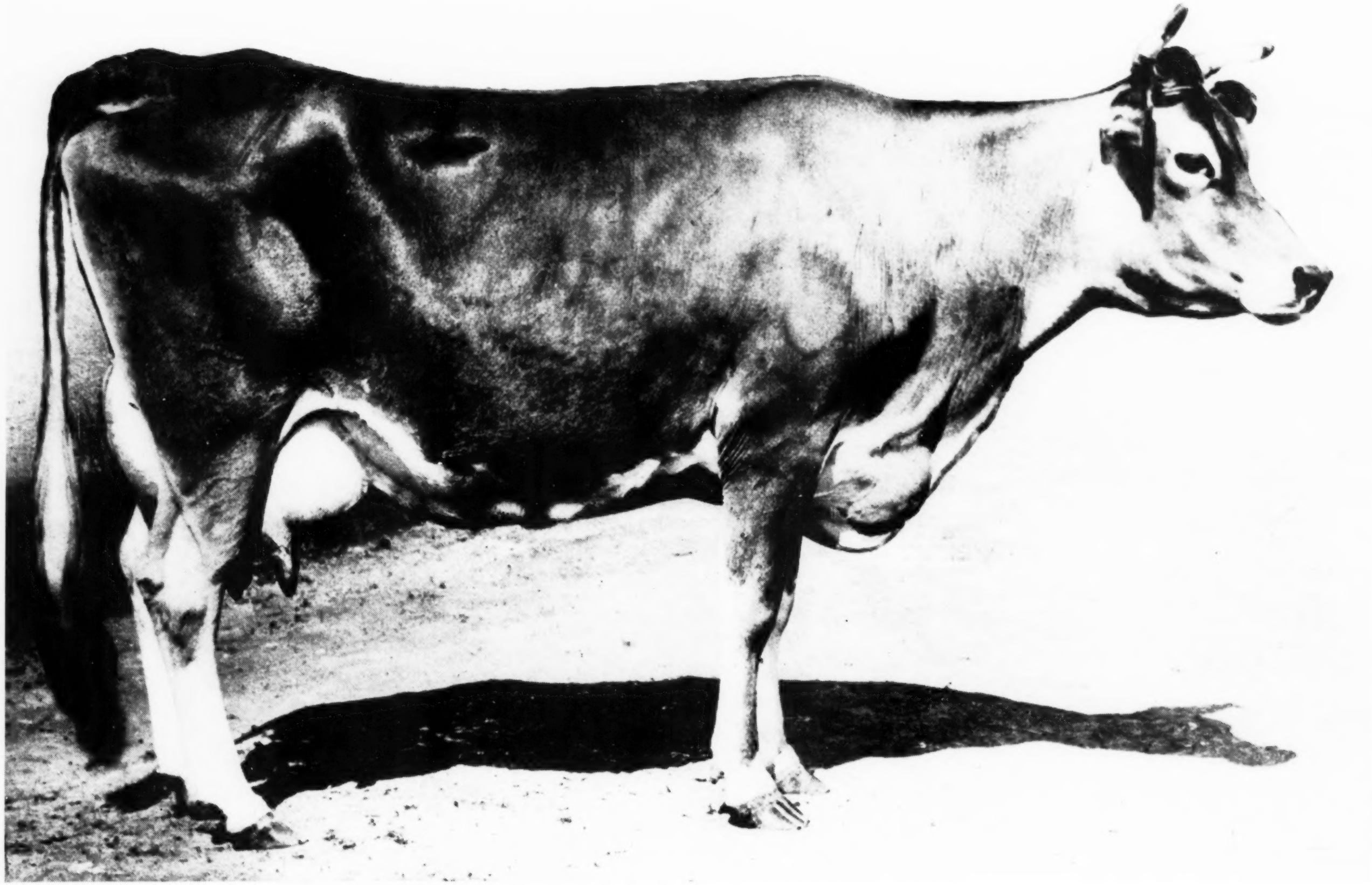
Before selection for butter-fat could be carried on scientifically a simple and accurate method of determining the fat content of milk was necessary. This was supplied by the Babcock Tester, which was invented in 1899 Since that time the increasing cost of feeds and the rising prices of dairy products have placed an ever-growing premium on the high producing cow.

Yearly records of milk and butter-fat production are available for only a relatively short time. In the Jersey breed the first world's record was that made by Dollies Valentine, champion from 1899 to 1905, with a production of 10,218 pounds of milk and 578 pounds of fat. Since that time the championship has changed hands much more frequently. Only one other cow has held the championship for as long as three years.

Not until thirteen years after Dollies Valentine relinquished her title was a thousand pounds of butter-fat produced by a Jersey record-holder in a single year, when in November, 1918, Sophie Agnes became champion with a record of one thousand pounds of fat and 16,212 pounds of milk. Since then the quantity of butter-fat has increased much more slowly, indicating that future progress will be more nearly comparable with that made in selection for speed of race-horses.

Up to the present time the comparison with speed has not been quite fair

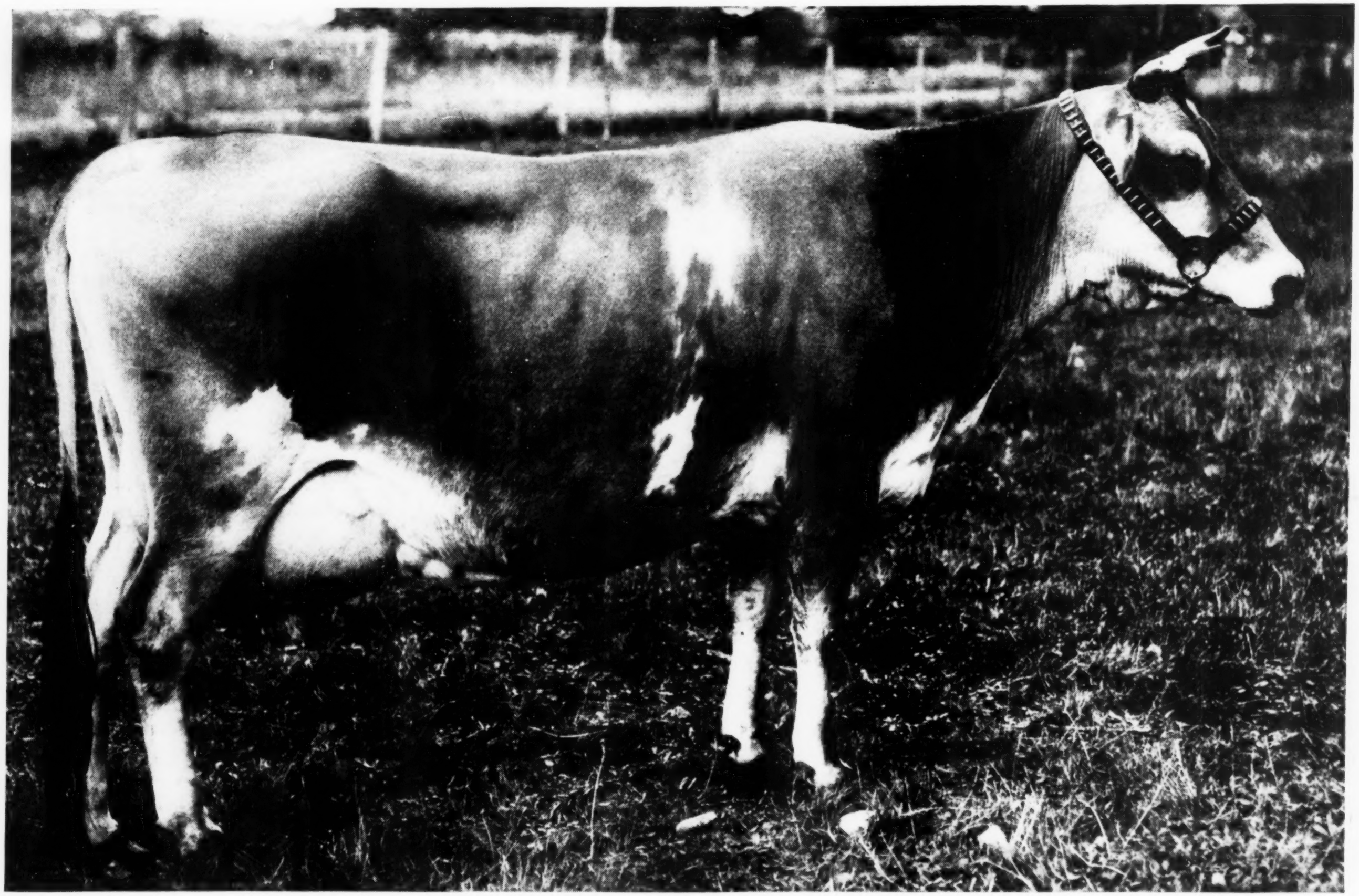
*Anderson, W. S. Journal of Heredity 12:134-137. 1921.



THE FIRST OF THE JERSEY RECORD HOLDERS

Figure 9

Dollies Valentine, who was first champion of the Jersey breed. She produced 10,218 pounds of milk and 517 pounds of butter-fat in a year.



THE PRESENT JERSEY CHAMPION

Figure 10

Darling's Jolly Lassie, whose record of 16,425 pounds of milk and 1,141 pounds of butter-fat makes her today the champion of the breed

to the horses, for the increased fat production has, perhaps, been due as much to better methods of feeding and management as to better breeding. Cows on test for advanced registry are given the best feed known to dairy science, and great advances have been made in feeding for milk production. Like education, feeding cannot take the place of good inheritance. Improved methods of feeding may increase the milk yield of a poor cow, but they cannot make her into a record-breaker.

Below are given the names and records of the champions of the Jersey breed, from the beginning of such tests to the present time.

Breed Improvement the Real Test of Progress

The maximum records made by a breed do not really tell the progress made in the improvement of a breed. The real improvement is told in the increase in *average production* of all cows in a breed. Unfortunately under the present system of official testing, breeders very often test only their best cows. Probably the time will soon come when breed associations will insist on a breeder's putting all the cows in his herd on test.

From the standpoint of intelligent selection it is just as important to know how many poor daughters (and how poor they were) a sire got as to know what his best daughters were. Nevertheless the study of the various world's record cows does to a certain extent measure progress in dairy cattle breeding. The pedigree of Darling's Jolly Lassie, the present holder of the world's record, shows that her high production is not a sport but rather the result of the mating of blood lines that carried an inheritance for great producing ability. Her dam was formerly the world's record four-year-old producer of the breed, with a record of 983 pounds of fat, and this dam was an inbred-75-per-cent-daughter of a sire that had four daughters with records of over 800 pounds of fat—one of them an ex-world's champion with 1,039 pounds of fat, and still another granddaughter was an ex-world's champion with 1,038 pounds of fat.

Mention has been made of the fact that Sophie Agnes was the first cow of this breed to produce 1,000 pounds of butter-fat. It is interesting to note that she took the world's record away from Sophie 19th of Hood Farm, who had a record of 999 pounds of fat, and furthermore that Sophie Agnes was a granddaughter of Sophie 19th of Hood Farm. Sophie Agnes was sired by a son of Sophie 19th of Hood Farm and this son sired many other high producing cows.

So that world's records in many cases are marks of intelligent selection and mating and this will probably be more true of future record-holders than of past.

Name	*Duration of Record*	*Year's Record* Milk, lbs.	Fat, lbs.
Dollies Valentine 105049	Feb. 24, 1899 to Jan. 23, 1905	10,218	578
Magyarlands Temisia 134765	Jan. 23, 1905 to Oct. 31, 1905	10,419	638
Emma's Rowena 146877	Oct. 31, 1905 to Jan. 31, 1907	10,383	638.25
Peer's Surprise 144248	Jan. 31, 1907 to Sept. 30, 1907	14,452	653
Olive Dunn 188832	Sept. 30, 1907 to June 7, 1908	9,930	671

Name	*Duration of Record*	*Years*	*Record*
		Milk, lbs.	*Fat, lbs.*
Financial Countess 155100	June 7, 1908 to Nov. 24, 1908	13,248	795
Adelaide of Beechlands 168699	Nov. 24, 1908 to Jan. 24, 1909	15,572	849
Jacoba Irene 146443	Jan. 24, 1909 to Sept. 13, 1911	17,253	952
Eniment's Bess 209719	Sept. 13, 1911 to Jan. 20, 1914	18,782	962
Sophie the 19th of Hood Farm 189748	Jan. 20, 1914 to Nov. 30, 1918	17,557	999
Sophie's Agnes 296759	Nov. 30, 1918 to Mar. 24, 1919	16,212	1,000
Vive la France 319616	Mar. 24, 1919 to Feb. 27, 1920	14,925	1,031
Plain Mary 268206	Feb. 27, 1920 to Apr. 7, 1922	15,256	1,040
Lad's Iota 350672	Apr. 7, 1922 to Feb. 17, 1923	18,632	1,048
Darling's Jolly Lassie	Feb. 17, 1923 to	16,425	1,141

Robert Cook.

THE CELL

A Review

PROFESSOR WILSON'S revised and enlarged treatise of "The Cell"* represents the untiring efforts of one of America's leading scientists to put before all students of biology a modern text on one of the most engrossing and progressive fields of science.

The rapid advances made in the fields of cytology are clearly evident in the expansion of the third edition to treble the thickness of the previous edition. Recent investigations have necessitated the rewriting of the greater part of the book and the interpellation of several new chapters. Typographical errors unfortunately occur but detract in no serious way from the real value of the text.

There is little room for criticism and ample reason to praise the masterly style and logical arrangement of this momentous text and reference book. The glossary, author's index and generous citations of literature all have helped to make this volume an indispensable desk encyclopedia.

Botanists hardly will be satisfied until a similar volume appears from the pen of some eminent leader in their field. Nevertheless they will not fail to appreciate the able discussions

*The Cell in Development and Heredity, by Edmund B. Wilson, Da Costa professor of zoology, Columbia University. Third edition revised and enlarged with 529 figures. Pp. 1232, price $9. The MacMillan Company, 1925.

and apt illustrations of botanical subjects that Professor Wilson weaves into his book to make it invaluable not to zoologists alone but to all biologists.

Professor Wilson has favored parsynaptic pairing in his discussion of the two types of synapsis. His arguments are ably presented, but in the light of very recent investigations it is the opinion of the reviewer that both types of synapsis occur.

It seems advisable to question the statement (p. 709) that chromoplasts produce anthocyanin since it is quite misleading. Such a relation between anthocyanin and chromoplasts, if it exists, is more indirect than the text would lead the reader to believe.

Modern research has associated the sex determining factor or factors, in representative forms from very diverse groups of organisms, with a definite *x* chromosome. Professor Wilson has led us to safer ground by showing us that this chromosome is only one part of a large controlling factorial complex in which are involved other chromosomes as well as cytoplasmic factors. The *x*-chromatin seems, in some manner to affect the metabolism of the cell. This view fits into the idea that sex in all organisms from the lowest to the highest is rooted in a quantitative plus and minus principle.

What is true for the sex chromosome applies in a similar manner to the autosomes, that is, "the whole germinal complex is directly involved in the production of each character." And so the chromosome theory of inheritance has for the biological sciences much the same kind of value as the molecular and atomic constitutions have for the physio-chemical sciences.

The road has been long and tedious that has led us finally to appreciate the controlling influence of the nucleus (chromosomes) in the development of the organism. We can not stop half way and attribute the details of development to the nucleus. The cytoplasm, which seems to control the rough pattern of development has hidden within it the effect of the nuclear control of previous generations and so it is the nucleus that governs the organism in its development.

The few paragraphs selected from chapters dealing with heredity and development illustrate the latest turns of the converging paths leading toward satisfactory solutions of some of the problems involved in the studies of heredity and development.

"The Cell in Development and Heredity" excels to such a degree that the reviewer searches in vain for words to express his appreciation of the author, who has gleaned from the studies of the past the fundamentals in cytology.

It does not suffice to say that this book is a milestone along the course in this rapidly developing branch of science. In addition it will be both the foundation and the structural framework that will steady the hand and direct the thoughts of students for years to come.

A. E. L.

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BUD SELECTION IN THE WASHINGTON NAVEL ORANGE

IV. Progeny Tests of Limb Variations of the Ribbed Strain

A. D. SHAMEL, C. S. POMEROY and R. E. CARYL
Bureau of Plant Industry, United States Department of Agriculture

BUD variations of the Washington Navel orange have been described and their relation to the origin and development of important strains of this variety has been discussed in an earlier publication.[1] Evidence showing that differences in both quantity of production and quality of crop of Washington Navel orange trees may occur as bud variations and that such variations may be perpetuated through bud propagation has also been published.[2] Another striking variation in fruit quality which has been found occurring as limb variations in trees of the Thomson and Washington strains will be described in the following pages.

The Ribbed Strain

The trees of the Ribbed strain of the Washington Navel orange have a similar habit of growth to those of the Washington strain except that they are normally more open, drooping and finely branched. The foliage of the Ribbed trees is less dense and the leaves are usually more sharply pointed than is the case with normal Washington trees.

The fruits of the Ribbed strain are usually globular or somewhat pyriform in shape and of medium to small size. The rind is thin and has a ribbed appearance, but is normally smooth in texture. The skin is usually dull orange in color, the rag is tender and small in quantity and the juice is fairly abundant but of inferior flavor and quality. The fruits are seedless and the navel opening is usually small.

Examples of this strain have been found to occur as occasional individual fruit variations in trees of the Washington and other navel orange strains and less frequently as limb sports in Washington and Thomson trees. Entire trees of the Ribbed strain have also been found in orchards of both the Washington and Thomson strains.

The commercial value of the fruits of the Ribbed strain is considerably less than that of fruits of the Washington strain. Their characteristic ribbed appearance and the dull color of the rind renders them less attractive than those of the Washington strain, the small size of the fruits is a distinct disadvantage from the market standpoint and their abnormal shape and uneven surface make their arrangement in commercial packages a difficult matter.

Ribbed Limb Variations

Three of the Ribbed limb variations studied in this investigation were found occurring in trees of the Thomson strain of the Washington Navel orange located on the Eureka ranch of the National Orange Company near Highgrove, California. Part of one of these trees including the Ribbed limb is shown at the left in Figure 11 and fruits from the Ribbed and normal portions of this tree are shown in Figure 12. The trees in this orchard were propagated by budding on Mission Sweet seedling rootstocks and were planted in 1902. No rebudding or top-working had been done previous to the beginning of the individual-

Parent Tree

Progeny Tree

PARENT AND PROGENY TREES OF RIBBED LIMB VARIATION

Figure 11

A tree of the Thomson strain of the Washington Navel orange grown from a single bud, which has a Ribbed limb variation. The ribbed oranges can be seen in the lower part of the photograph in contrast to the smooth ones above. This is tree 1-27-5 as listed in Table 1 and fruits from it are shown in Figure 12. A progeny tree propagated in 1915 from this Ribbed limb is shown at the right. Photographed at Riverside, Cal., January, 1923.

FRUITS OF THE RIBBED LIMB VARIATION

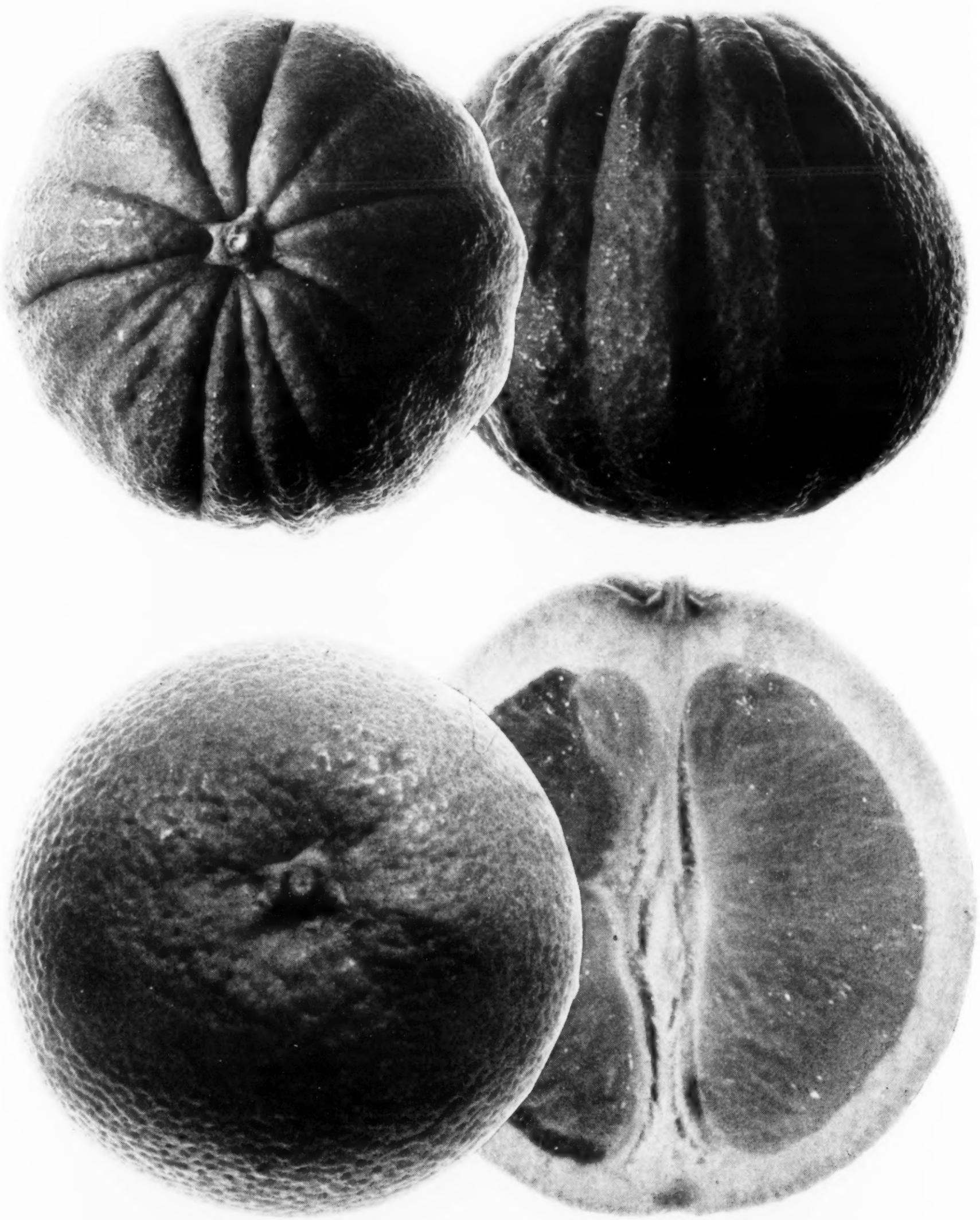
Figure 12

The ribbed fruits from the limb variation are compared with normal fruits from other parts of the same tree.

RIBBED FRUITS FROM PROGENY TREE

Figure 13

Ribbed fruits produced by the progeny tree shown at the right in Figure 11. All the characters of the parent form are perpetuated by vegetative propagation.



FRUIT FROM TOPWORKED TREES

Figure 14

In addition to the progeny trees propagated from the Ribbed limb variations, normal trees were topworked with ribbed and normal budwood. The fruits shown here were produced by two topworked trees. In one of these budwood from a Ribbed limb variation was used, and in the other budwood from the normal part of the tree having the Ribbed limb. This control tree produced all Washington fruit, and the other all Ribbed fruit.

tree performance-record work which was started in 1910. The orchard was planted on virgin land and little or no fertilizer had been used up to the time when these studies were undertaken. Winter cover crops of common vetch (*Vicia sativa*) were grown each year and plowed under early in the spring. The soil, lay of the land, and other environmental conditions were favorable to the development of crops of superior commercial quality which has been reflected in the relatively high prices obtained for them each year.

The fourth Ribbed limb variation included in this report was found in a tree of the Thomson strain on the ranch of the Corona Lemon Company at Corona, California, in an orchard which was planted about 1900, in which no top-working had been done.

The trees in which these Ribbed limb variations occur are typical of the Thomson strain of the Washington Navel orange, except for the one variable limb on each tree. These limb variations were first discovered in 1910 and since that time they have consistently produced typical ribbed fruits each year.

Progeny Propagation

In 1915 budwood was secured from the three Ribbed limb variations on the Eureka ranch and from the normal Thomson part of one of the parent trees and was propagated on sour orange seedlings in a commercial nursery under a co-operative arrangement with the Citrus Experiment Station of the University of California. The nursery trees were transplanted July 2, 1917, to the progeny orchard in the variety block at the Citrus Experiment Station, Riverside, California. These progenies consist of two trees from each of the Ribbed limbs and two trees from the normal part of one parent tree, as mentioned above. The right portion of Figure 11 shows one of the progeny trees propagatd from the Ribbed limb shown in the tree at the left, and Figure 13 shows typical fruits produced by this progeny tree.

The trees were planted ten feet apart in the same row under comparatively uniform environmental conditions and have been given normal cultural care continuously. Winter and summer legume cover crops have been grown in the orchard each year and plowed under. The trees have made a vigorous and healthy growth.

In February, 1916, propagations were made from a fourth Ribbed limb variation and from the normal portion of the same parent tree. One progeny tree of this Ribbed limb and two trees of the normal Thomson strain were planted in May, 1917, in the same orchard with the older progeny trees at the Citrus Experiment Station.

Progeny Performance Records

The crops from each progeny tree have been recorded separately each year since the trees came into bearing, the number of fruits being listed according to their strain characteristics. These performance-records as presented in Table I show that the ribbed characteristics of the fruits of the limb variations in the parent trees were of an inherent nature and that they have been transmitted through asexual propagation to their progenies.

The two progeny trees which were propagated from the Ribbed limb variation in parent Thomson tree 1-25-7 have produced totals of 193 and 325 oranges respectively during the five seasons 1920-21 to 1924-25 inclusive. All of these fruits have been similar to those borne by the parent limb variation and typical of the Ribbed strain as is shown in Figure 13.

As shown in Table I, all the progeny trees which were propagated from Ribbed limb variations in Thomson trees produced fruits which have been similar to those of the parent limb variation and typical of the Ribbed strain.

Top-Working Experiment

In addition to the progeny tree studies described in the foregoing paragraphs, a top-working test of the Ribbed strain was also made. A limb variation found in 1910 in an eight-year-old tree of the Washington strain in the Eureka orchard of the National Orange Company of Riverside, California, was propagated that spring by top-working on a neighboring normal bearing tree of the Washington strain. As soon as the buds from the parent Ribbed limb variation became united with the limbs in which they were placed, the original head of the tree was cut away just above the inserted buds and only growth from these buds has been allowed to remain, the present tree-top being made up entirely of growth from the Ribbed buds.

This top-worked tree came into bearing in 1913, producing a few fruits which were all ribbed, similar to the parent limb variation and typical of the Ribbed strain. While no record has been kept of the number of fruits produced by this tree, observations each year have shown that its crops have been made up entirely of ribbed fruits.

Buds were also taken from a normal branch of this parent Washington tree at the same time that those from the Ribbed limb were cut and they were used as a check in top-working another nearby tree of the Washington strain.

The growth from these buds has been entirely normal and all of the fruits produced by the resulting tree have been typical of the Washington strain and similar to those of the parent branch from which the buds were secured. Fruits from this control tree, and from the tree top-worked with Ribbed budwood are shown in Figure 14.

Buds from this same Ribbed limb variation were taken to San Dimas, California, in 1912, by the late Mr. G. W. Hosford and two trees were grown from them on sweet orange stock, both of which produced fruit of the same character as the parent limb.

The results in this earlier top-worked and budded experiment were similar to those secured later from the progeny tree studies in showing that the characteristics of the parent Ribbed limb variation were transmitted by budding and that the characteristics of the normal part of the parent Washington tree were also perpetuated through bud propagation.

Conclusion

The results of these tests indicate that the characteristics of the Ribbed strain of the Washington Navel orange found as limb variations have been transmitted to progeny trees.

These studies suggest the probability that the presence of trees of diverse strains in established citrus orchards are often the result of the unintentional propagation of limb variations in normal nursery operations.

These progeny tests and those previously reported emphasize the great importance of careful bud selection in the commercial propagation of citrus trees in order to avoid the propagation of undesirable strains.

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1. Shamel, A. D., Scott, L. B., and Pomeroy, C. S., Citrus-Fruit Improvement: A Study of Bud Variation in the Washington Navel Orange. *U. S. Dept. Agr. Bul.* 623, 146 p., illus. 1918.

2. Shamel, A. D., Pomeroy, C. S., and Caryl, R. E., Bud Selection as Related to Quantity Production in the Washington Navel Orange. *Jour. Agr. Research*, 26:319-322, illus. 1923.

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TABLE I—Records of annual production of progeny trees propagated from limb variations of the Ribbed strain of the Washington Navel orange and of trees propagated from the normal Thomson portion of two of the same parent trees. All of the fruits borne by these progeny trees have been typical of the strain that was propagated

Strain	Tree No.	Number of Fruits Produced*					
		1920-21	1921-22	1922-23	1923-24	1924-25	Totals
Progeny of Ribbed limb	1	2	0	75	115	1	193
in Thomson tree 1-25-7	2	4	21	69	229	2	325
Progeny of Ribbed limb	3	27	85	141	273	193	719
in Thomson tree 4-17-11	4	36	143	100	168	132	579
Progeny of Ribbed limb	5	35	101	37	94	93	360
in Thomson tree 5-33-4	6	45	147	96	119	116	523
Progeny of normal Thom-	7	30	157	93	223	140	643
son limb in tree 5-33-4	8	14	62	56	95	47	274
Progeny of Ribbed limb in Thomson tree 24-1	9			19	24	24	67
Progeny of Thomson por-	10			41	106	128	275
tion of tree 24-1	11			25	120	140	285

*Trees 1 to 8 inclusive were planted July 2, 1917, and trees 9 to 11 were planted in May, 1919.

Babies Versus Pigs

The *Washington Evening Star* of September 1, 1925, published the following special dispatch from Winchester, Virginia:

Peace prevailed as the fifty-sixth annual fair opened here today, after a two-week controversy over the merits of pigs and babies, which started when someone discovered that the Shenandoah Valley Agricultural Society, which promotes the fair, had appropriated more prize money for pigs, than had been offered for the baby show.

The situation was saved when champions of the babies made up additional purses.

AN ALFALFA BUD MUTATION

A White-Flowered Alfalfa Branch Found Upon a Lavender-Flowered Plant

L. R. WALDRON
North Dakota Agricultural Experiment Station

MANY investigators have reported cases in which a single branch, traceable back to some hypothetical bud, has been so unlike the remaining portion of the plant that its genetical difference has hardly been questioned. In some cases, indeed, such a difference has been established by breeding experiments. These bud mutations have been found in many plant groups. No doubt many have been overlooked because they have differed only slightly from the parent stock. Most of these somatic mutations resemble those of a germinal nature in that they are concerned mainly with the appearance of recessive characters, indicating that dominant factors have become modified or "lost." In most cases, the genetic constitution of the plant producing the bud mutation has not been known and usually no genetic analysis has been made after the appearance of the aberrant limb.

The case which is here reported occurred in alfalfa, *Medicago sativa*. In July, 1920, at Fargo, North Dakota, an alfalfa plant with lavender flowers was found to have one branch, originating from the crown, which bore pure white flowers.

The lineal history of this plant is known in part and is briefly as follows: In 1914, Chas. C. Haas, of Whitewood, South Dakota, sent the writer a small quantity of alfalfa seed called by him "albino." He stated that this came from a plant producing only pure white flowers which lacked even the violet veining in the petals of the young flowers, usually found in so-called white-flowered alfalfa. The color of the seeds was very striking as they seemed to be nearly or quite lacking in pigment. Their very light color contrasted strikingly with the rather richly pigmented seeds of normal alfalfa. The plant from which the "albino" seed was secured was said by Mr. Haas to have been the only plant of its kind growing in a fifteen-acre field on his farm in the Black Hills region. Subsequently, in another field, seeded with seed obtained from the fifteen-acre field, before the finding of this white-flowered plant, three other similar plants were found. The original seed traces back, many years, to Utah sources. Mr. Haas, apparently a keen observer, has never found other alfalfa plants similar to the four mentioned, even after diligent search in many fields. The writer knows of no record in the literature of alfalfa plants bearing pure white flowers and nearly pigment-free seeds.

True albino alfalfa plants are found not uncommonly among young seedlings, but they soon die because of lack of chlorophyll. The kind dealt with in this paper resembles ordinary alfalfa with respect to foliage. The term "flower-seed albino" is suggested for this type in which the lack of color does not extend to leaves and stems, but is confined to the flowers and seeds. Such flower-seed albinos have been reported as occurring in common red clover, but apparently not all white-flowered red clover plants are of this type. Closer examination may show those clover plants with white flowers and pigmented

seed to carry a slight amount of color in the flower. Such plants would thus correspond to ordinary white-flowered alfalfa.

The seeds received from Mr. Haas were planted alternately with plants of the yellow-flowered *Medicago falcata* in a plat geographically isolated from other alfalfa. Seeds from the albino plant all produced plants having violet flowers, which indicated a back-cross with ordinary violet-flowered parents, violet color being dominant. Seed of these F_1 violet-flowered plants was pigmented in the ordinary manner. In the second generation, of a total of 1,943 plants having non-*falcata* parentage, only twenty or less than one per cent, were flower-seed albinos. This is less than the number required if as many as three factors were present for color. Selfed seed was obtained from certain of the flower-seed albinos, and this was similar to that originally obtained from Mr. Haas. This seed, when planted, produced plants like the parent plants. The plant in which the bud mutation occurred, was one of a number of plants which grew from seed of a flower-seed albino subject to open pollination with plants of the same descent.

The cell from which the mutated branch was derived was evidently heterozygous for flower color for one, two, or three factors. It is likely that only one factor was present for color. This was either modified to one for an albino condition or it is not impossible that in one of the early cell divisions certain irregularities in mitosis arose which permitted one of the daughter cells to receive only factors for the albino condition. There is no normal method of segregation occurring in the somatic cells to account for such a result, but Blakeslee, Belling and Farnham have suggested that a process corresponding to double non-disjunction might possibly take place among the chromosomes immediately after the first division following the reduction division in tetraploid Daturas. Corresponding results might conceivably occur in somatic diploid cells, but apparently there is no evidence of the occurrence of such a phenomenon.

If the cell from which the mutated branch arose was unique in its modification, it seems rather remarkable that it, out of many others, should be the one giving rise to the branch in question. Obviously many of the somatic cells could mutate without the fact becoming evident.

It is not certain, of course, that the albino plant found by Mr. Haas represented an original mutation. Inasmuch as it seems to have been the only alfalfa plant of that nature ever known or recorded, it is likely that it was the original mutation and not the descendant of an albino ancestor of one or more previous generations. The nearly white seed of the plant would be a striking feature if found mixed with commercial seed. It is known that considerable self-fertilization takes place in alfalfa, enough to bring albino plants of this sort to the surface if genes responsible for them are present in the germ plasm. Even if cross fertilization in alfalfa were universal, flower-seed albinos would be expected to appear occasionally if factors for the character were present.

As three factors, at any rate, were evidently responsible for violet flower color, the original mutation was probably much more profound than the one herewith described. In the original mutation at least six factors (three factors each of the duplex condition) must have been modified, either at one time or successively, while in the case at hand one need not assume more than one factor to have become modified.

POMOLOGY FOR PLANT BREEDERS

A Review

A GOOD systematic pomology has been badly needed by students and workers in horticulture and especially by plant breeders. Horticulturists at the New York agricultural experiment station, of whom the author of this book* is the leader, have had an unequaled opportunity to study living material of fruit varieties and species which are essential in the preparation of a work of this kind. Moreover in compiling their monographs on the various fruits of New York they have had long experience in this type of work.

The book is undoubtedly the most valuable in its field. Only the hardy fruits are included. The first part properly discusses roots, stems, buds, leaves, flowers, and fruits; a description of the genus and species, a varietal descriptive blank, the habitat and history of each group follows; while the latter part of the text is devoted to variety descriptions. An especially valuable part is the key to varieties of apples, pears, quinces, apricots, cherries, nectarines, peaches, plums, and grapes. Keys to species of the various fruits are also helpful.

The weakness of the book as a text is the lack of a critical attitude in handling the literature and subject matter. For example, on page 180 the black raspberry species, *R occidentalis,* is described. In the next paragraph the habitat of the black raspberry is given as westward to Oregon, Washington, and British Columbia. However, the species of black raspberry in Oregon, Washington, and British Columbia is not *R. occidentalis* as would be inferred but *R. leucodermis.* Other black raspberry species occur in Central and South America and in Asia but are not mentioned.

In a description of the species, *R idaeus* and *R. strigosus* the former is said to have nearly straight slender prickles while those of *R. strigosus* are said to be stiffer. Card, in "Bush Fruits," p. 167, holds that the reverse is true, while Bailey in Gentis Herbarium, and Focke in Species Ruborum describe *R. idaeus* as having strong prickles broadened at the base, and *R. strigosus* as bearing slender bristles. It is also stated that the tendency to fruit continuously is lacking in *R. strigosus.* However, *R. strigosus* has frequently been observed fruiting freely during late summer and fall in various parts of New England, New York, and Wisconsin. Ranere, a continuous fruiting variety described in the text, is a selection of *R. strigosus* from New Jersey.

The author's classification of raspberry varieties is also misleading. Many varieties referred to *R. strigosus* are almost entirely lacking in glandular hairs. Their history and botanical characters indicate that they are hybrids between the European and American species as discussed in this Journal (Vol. XI, pp. 179-184).

Rubus laciniatus, the Evergreen blackberry described on p. 183, is said to be of little commercial importance in America. On the contrary, it is one of the four most important blackberry varieties. The Evergreen and Logan are by far the leading varieties in Oregon and Washington. The Evergreen is also the leading sort in southern New Jersey.

On page 185 the old name *Rubus invisus* is preserved yet Brainerd and

*HEDRICK, U. P., Systematic Pomology, pp. xvii, 483. The MacMillan Company, New York and London, 1925.

Petersen have shown it to be a blend species and have referred the form apparently described to *Rubus baileyanus x flagellaris*. Both dewberry and blackberry species of importance to pomologists as sources of horticultural varieties are not mentioned.

Many details in the discussion of varieties of blackberries are misleading. Of the Kittatinny it is said (p. 431) "Possibly no variety has been or is more widely and largely grown." In a canvas of many nurseries during the past few years it has been impossible to secure plants of this variety. It is certainly of very minor commercial importance at present.

Under the heading "Sports or Mutations from root-cuttings," (p. 7) the statement is made "Blackberries are commonly propagated from root-cuttings and most varieties come true; some sorts, however, do not, the most commonly reported cases being Erie, Eldorado, Wilson Junior, and Rathbun." Unless well suported such a statement should hardly be placed in a text for students. If evidence is available it should be published. However, blackberry varieties in many nurseries are badly mixed. In no case has the reviewer seen plants of the Erie purchased from nurseries true to name. All were Rathbun. In New York and New England it has been difficult to secure Eldorado true to name. The source from which nurserymen in those states have secured their stock apparently had plants untrue to name and all cases attributed to sports can probably be explained by such mixtures.

For the most part the discussion of the strawberry is good. However, it is stated (p. 207) that no valuable varieties have come from the North American form of *F. chiloensis*. Both Etter and Georgeson have used it in securing their valuable new sorts. On page 208 the Alpine is called the wild strawberry of Europe. Yet *F. vesca* is the wild strawberry of Europe and the Alpine is the everbearing botanical variety of it which is supposed to have originated in Northern Italy. It is further stated that the Alpine often gives everbearing varieties which are cultivated in Europe. Horticultural varieties of the Alpine are cultivated in Europe but the history of European everbearing varieties of the common garden type render it doubtful whether they are derived from the Alpine.

Other comments might be made on the discussion of the strawberry. Thus no descriptions are given of several of the most important commercial varieties, such as Howard 17 (*Premier*), Parsons (*Gibson*), Sample and Oregon, while varieties of little importance, such as Ford, Peerless, and Rough Rider are included. Crescent is described and is said to be found in the eastern states, yet a search of several years has failed to obtain it in this country.

As an authoritative text it leaves much to be desired.—G. M. Darrow.

Iowa Lists 100,000 Residents of State Unfit to Marry

Des Moines, Iowa, September 30.—The State Board of Control Bureau of Child Welfare which is listing Iowans who are ineligible to marry, announced Monday that approximately 100,000 names will appear on the list.

These persons are inmates of State insane asylums or hospitals, and under the law "those whom the board knows to be unfit for marriage." —*Associated Press.*

HERITABLE CHARACTERS OF MAIZE

XXIV—Twisted Seedlings*

PAUL KVAKAN
Agricultural Experiment Station, Cuprija, Jugo-Slavia

SEEDLINGS OF TWISTED MAIZE
Figure 15

Three examples of the strain called twisted—1. With the exception of the seedling at the extreme left, the plants are near to the full restoration of the normal phenotype. Though similar in appearance, this abnormality is genetically distinct from those illustrated in Figures 16 and 17.

THE first reference to twisted seedlings was made by Hutchison[1] from whom the writer obtained the material used in this study. The results of experiments made up to the present time, indicate that three of the twisted types are genetically different. They will be designated as twisted—1 (*Tw*$_1$ *tw*$_1$), *twisted*—2 (*Tw*$_2$ *tw*$_2$) and twisted—3 (*Tw*$_3$ *tw*$_3$). Twisted—1 was found in a variety of maize obtained from H. K. Hayes of Minnesota

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SEEDLINGS OF TWISTED-2

Figure 16

Four plants of twisted—2 are shown. The two variants on the left apparently are without much chance of recovery. On the right are two fully recovered plants.

Agr. Exp. Sta.; twisted—2 came from Isbell Seed Co., Michigan; while twisted—3 was obtained from the material sent by D. F. Jones of Connecticut Agricultural Experiment Station.

Description of Twisted Seedlings

The character shows in the very earliest stage of the growth of the seedling in a pronounced twisting of the first leaves, their attachment to each other and failure to unfold normally, as can be seen from the illustrations. This usually results in the formation of a more or less defined loop which may be either single or double, according to whether two or more leaves are involved in its formation. In most cases the loop opens spontaneously, and the new leaves develop normally, producing a plant which later cannot be distinguished from normal plants.

The individual deformation in the same family, however, is subject to extreme variability. The accompanying photographs illustrate the wide range of variation existing among the seedlings of such a progeny. It is obvious that all the abnormal individuals of one ancestor do not necessarily pass thru all the grades and changes in the progress toward the final appearance of a normal plant. As a matter of fact, some of the plants never recover and perish early if the deformation is too pronounced, while in the others the abnormality is only ephemeral.

SEEDLINGS OF TWISTED-3

Figure 17

The plants on the left and in the middle present a fairly average picture of tw_3. They usually have good chances for an early recovery. The plant on the right is almost normal.

The Inheritance of Twisted Seedlings

From the data on inheritance of twisted seedlings, the conclusion can be drawn that they are inherited as simple Mendelian recessives. A back cross of $Tw_1\ tw_1$ with $tw_1\ tw_1$ produced 173 normal to 154 twisted seedlings, a deviation from the expected equality of only 9.5 ± 6.04. Similarly, F_2 progenies of $Tw_1\ tw_1$ had 540 normal and 209 twisted seedlings, a deviation from the numbers expected on the basis of a 3:1 relation of 21.75 ± 7.99. The back cross $Tw_2\ tw_2 \times tw_2\ tw_2$ gave 222 normal to 192 twisted plants, the deviation from equality being 15 ± 6.86. F_2 progenies of $Tw_3\ tw_3$ had 520 normal and 154 twisted individuals, a departure from the 3:1 relation of 14.5 ± 7.58.

Intercrosses of the three stocks of twisted justify the conclusion that, though similar in appearance, they are genetically distinct. Intercrosses were made with heterozygous plants, and the methods used are those described by Demerec.[2] The cross of tw_1 with tw_2 gave 34 normal plants. From the cross involving tw_1 *and* tw_3 48 normal plants were produced. This is considered to be a good preliminary test to indicate that tw_1 is different from tw_2 and tw_3. Only a few F_1 seeds of the cross $tw_2 \times tw_3$ have been tested, but they developed into normal plants. The F_2 generation of this cross consisted of 296 normal and 190 twisted plants, a departure from the expected 9:7 ratio of 22.6 ± 7.38. These data

also indicate that there is no close linkage between *tw*₂ and *tw*₃.

Though no systematic test for linkage has been made so far, there are some results available to show that *tw*₁ and *tw*₂ are probably not linked with the factor for brown aleurone (*Bn*), and that the same is true for *tw*₂ and the factor for yellow endosperm (*Y*). There are indications of a close linkage between *tw*₂ and a glossy seedling (undescribed so far). The final conclusion must, however, await additional data. The glossy involved here is different from the one linked with *Bn*.[3] Sufficient data are available to show an apparently independent segregation of the factor *tw*₃ from *Y*, *su* (sugary endosperm) and *sh* (shrunken endosperm).

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The Cultivated Plants of the United States

A Manual of Cultivated Plants, by L. H. Bailey. 851 pages, price $7.00. The MacMillan Company, New York and London, 1924.

Among the many new books designed to assist horticulturists and others interested in cultivated plants none is of greater importance than this manual prepared by the leading authority in the field. Research workers will find it invaluable as they have the Standard Cyclopedia of Horticulture by the same author. Furthermore it is the only manual of the kind in any language.

As the author states, the purpose of the book is to provide a ready means for the identification of the species in the usual domestic flora of the continental United States and Canada. It includes 3,665 species and 1,246 genera. Species of rather recent introduction that promise to be acquisitions but which are not yet well known, as well as some of great historic interest in Europe and other countries but are little cultivated in North America are included and greatly increase the value of the manual. Keys enable one to trace out any cultivated plant.

Nothing but praise can be given to a work of this kind. Undoubtedly specialists in various groups can and will help to make later editions still more accurate and useful. Plant introduction has proceeded at so rapid a rate that it cannot be possible to have all cultivated plants of this country included. It is a great book written by the one best fitted for it and by one of the few who would have the courage to undertake such a work. In behalf of plant breeders the reviewer expresses his appreciation to the author and editors for this book.

G. M. D.